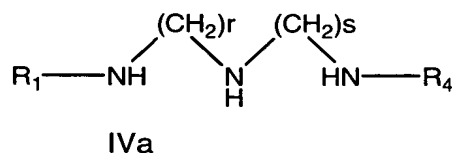
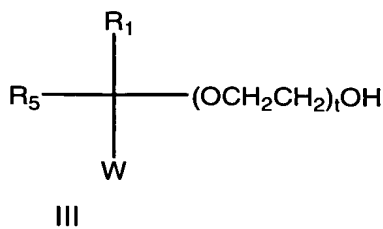
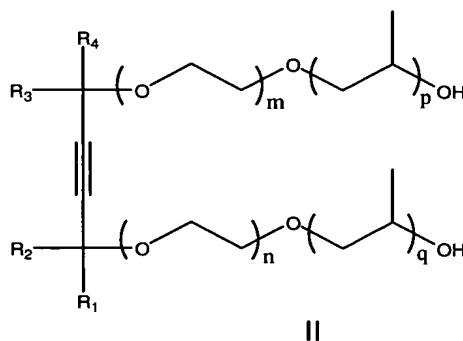
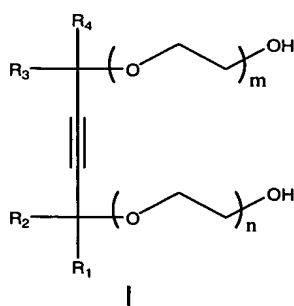
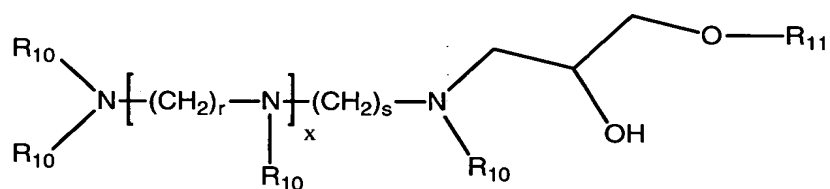
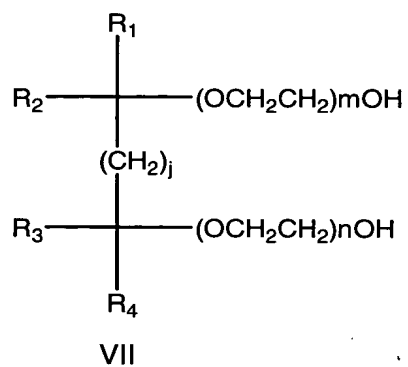
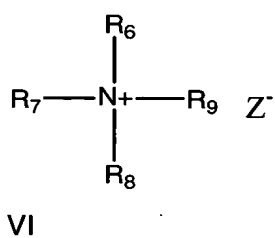
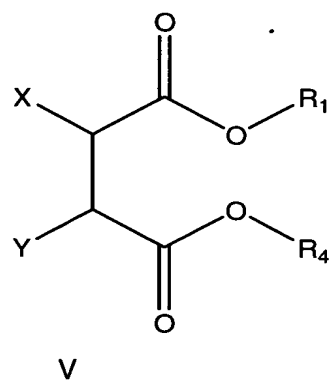
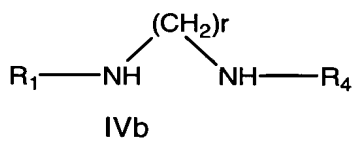


# CLAIMS

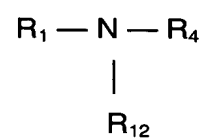
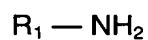
We claim:

1. A method for reducing the number of defects during the manufacture of semiconductor devices, the method comprising:
  - providing a substrate comprising a photoresist coating;
  - exposing the substrate to a radiation source to form a pattern on the photoresist coating;
  - applying a developer solution to the substrate to form a patterned photoresist coating;
  - optionally rinsing the substrate with deionized water; and
  - contacting the substrate with a process solution comprising at least one aqueous solvent, at least one non-aqueous solvent that is miscible in an aqueous solvent, and about 10 ppm to about 10,000 ppm of at least one surfactant having the formula (I), (II), (III), (IVa), (IVb), (V), (VI), (VII), (VIII), (IXa), (IXb), (IXc), (Xa), (Xb), (Xc), or (Xd):





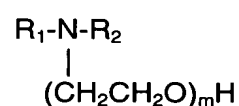
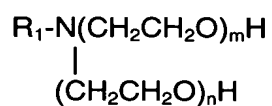
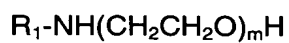
VIII



IXa

IXb

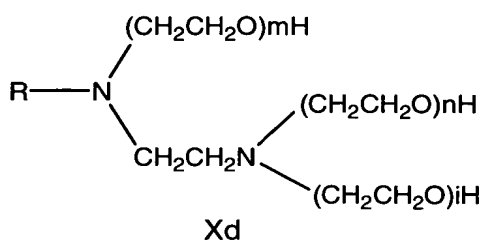
IXc



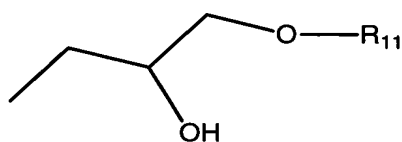
Xa

Xb

Xc



wherein R, R<sub>1</sub>, R<sub>4</sub>, and R<sub>12</sub> are each independently a straight, a branched, or a cyclic alkyl group having from 3 to 25 carbon atoms; R<sub>2</sub> and R<sub>3</sub> are each independently a hydrogen atom or an alkyl group having from 1 to 5 carbon atoms; R<sub>5</sub> is a straight, a branched, or a cyclic alkyl group having from 1 to 10 carbon atoms; R<sub>6</sub> is a straight, a branched, or a cyclic alkyl group having from 4 to 16 carbon atoms; R<sub>7</sub>, R<sub>8</sub>, and R<sub>9</sub> are each independently a straight, a branched, or a cyclic alkyl group having from 1 to 6 carbon atoms; R<sub>10</sub> is independently H or a group represented by the formula



; R<sub>11</sub> is a straight, a branched, or a cyclic alkyl group

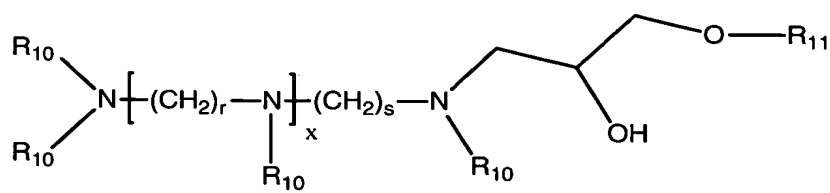
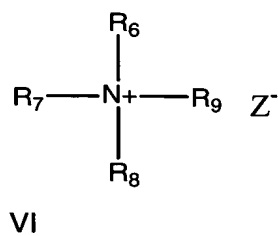
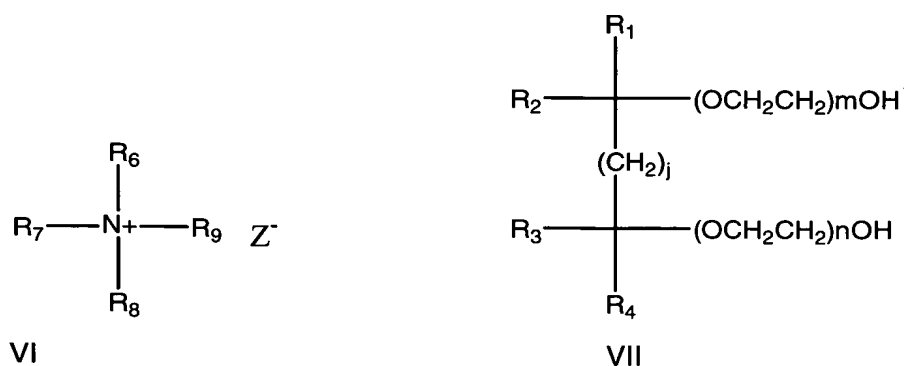
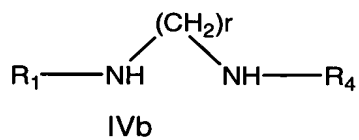
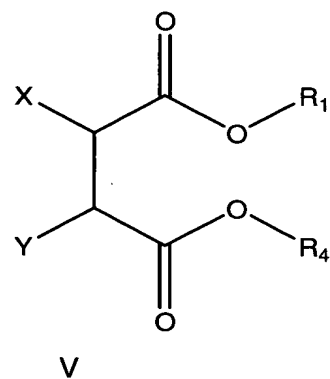
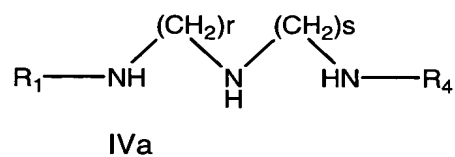
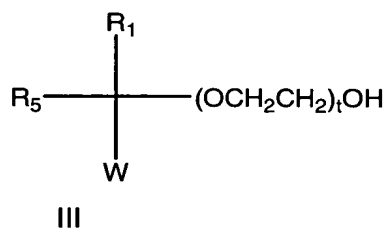
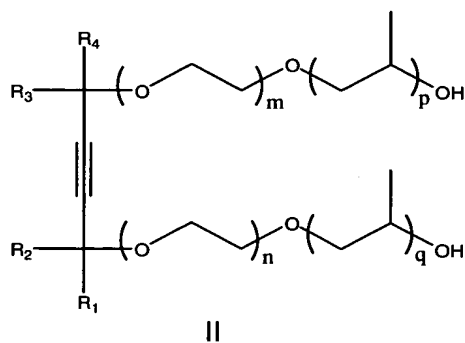
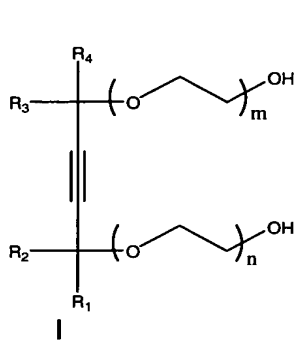
having from 4 to 22 carbon atoms; W is a hydrogen atom or an alkynyl group; X and Y are each independently a hydrogen atom or a hydroxyl group; Z is a halide atom, a hydroxyl group, an acetate group, or a carboxylate group; i, m, n, p, and q are each independently a number that ranges from 0 to 20; r and s are each independently 2 or 3; t is a number that ranges from 0 to 2; j is a number that ranges from 1 to 5; and x is a number that ranges from 1 to 6.

2. The method of claim 1 wherein the contacting step comprises a dynamic rinse.

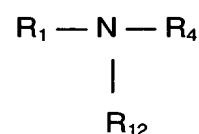
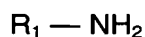
3. The method of claim 1 wherein the contacting step comprises a static rinse.

4. The method of claim 1 wherein the surface of the substrate in the contacting step is wet with the developer solution.

5. The method of claim 1 wherein the surface of the substrate in the contacting step is wet with the deionized water rinse.
6. The method of claim 1 wherein the process stream is formed by injecting 10 to 10,000 ppm of the at least one surfactant into the solvent.
- 5 7. The method of claim 1 wherein the process stream is formed by applying 10 to 10,000 ppm of the at least one surfactant onto the surface of the substrate and applying the solvent to the substrate surface.
8. The method of claim 1 wherein the process stream is formed by passing the solvent through a cartridge comprising the at least one surfactant.
- 10 9. The method of claim 1 wherein a time of the contacting step ranges from 1 to 200 seconds.
10. The method of claim 9 wherein the time of the contacting step ranges from 1 to 150 seconds.
11. The method of claim 10 wherein the time of the contacting step ranges from 1 to 40 seconds.
- 15 12. The method of claim 40 wherein an at least one temperature of the contacting step ranges from 10 to 100°C.
13. A method for avoiding a collapse of a developed pattern on the surface of a plurality of substrates, the method comprising:
- 20 providing a first substrate comprising a photoresist pattern developed upon the surface;
- preparing a process solution comprising from 10 ppm to about 10,000 of at least one surfactant having the formula (I), (II), (III), (IVa), (IVb), (V), (VI), (VII), (VIII), (IXa), (IXb), (IXc), (Xa), (Xb), (Xc), or (Xd):



VIII

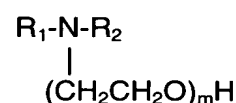
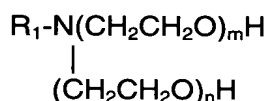
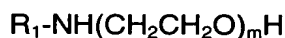


5

IXa

IXb

IXc

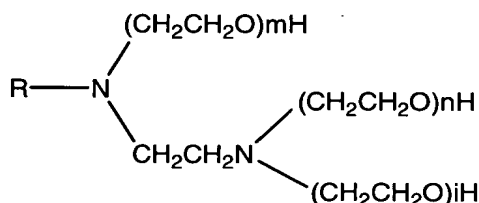


10

Xa

Xb

Xc

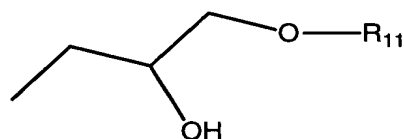


15

Xd

wherein R, R<sub>1</sub>, R<sub>4</sub>, and R<sub>12</sub> are each independently a straight, a branched, or a cyclic alkyl group having from 3 to 25 carbon atoms; R<sub>2</sub> and R<sub>3</sub> are each independently a hydrogen atom or a straight, a branched, or a cyclic alkyl group having from 1 to 5 carbon atoms; R<sub>5</sub> is a straight or a branched alkyl group having from 1 to 10 carbon atoms; R<sub>6</sub> is a straight or a branched alkyl group having from 4 to 16 carbon atoms; R<sub>7</sub>, R<sub>8</sub>, and R<sub>9</sub> are each independently a straight or a branched alkyl group having from 1 to 6 carbon atoms; R<sub>10</sub> is independently a H atom or a group represented by

20



the formula

; R<sub>11</sub> is a straight, branched, or cyclic alkyl

group having from 4 to 22 carbon atoms; W is a hydrogen atom or an alkynyl group;

25

X and Y are each independently a hydrogen atom or a hydroxyl group; Z is a halide atom, a hydroxyl group, an acetate group, or a carboxylate group; i, m, n, p, and q are each independently a number that ranges from 0 to 20; r and s are each

independently 2 or 3; t is a number that ranges from 0 to 2; j is a number that ranges from 1 to 5; and x is a number that ranges from 1 to 6;

contacting the first substrate with the process solution;

determining a surface tension and a contact angle of the process solution  
5 on the first substrate;

multiplying the surface tension by the cosine of the contact angle to  
provide the adhesion tension value of the process solution;

providing the plurality of substrates wherein each substrate within the  
plurality comprises a photoresist pattern developed upon the surface; and

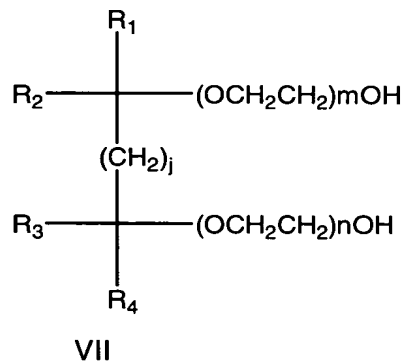
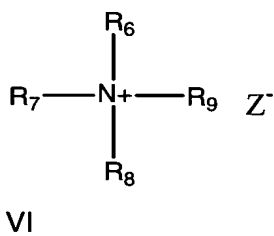
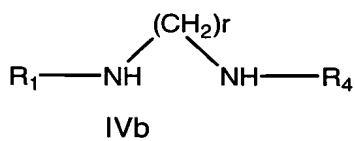
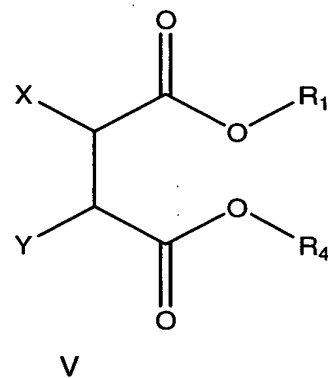
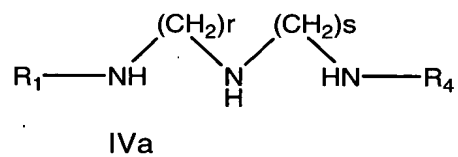
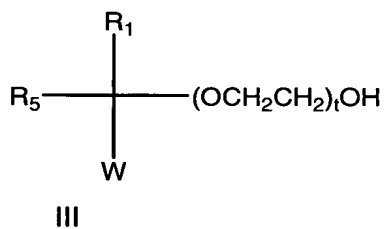
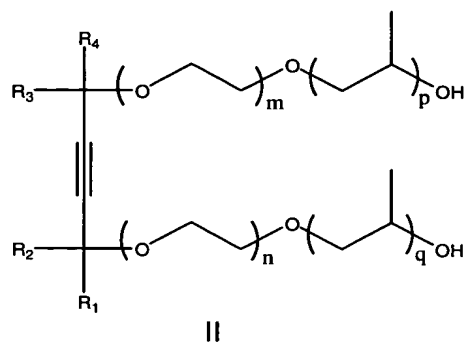
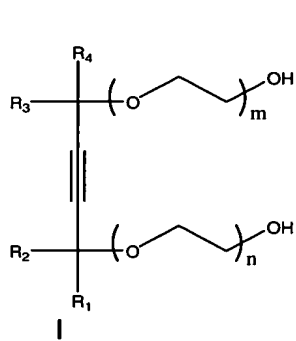
10 contacting the plurality of substrates with the process solution if the  
adhesion tension value of the process solution is 30 or below.

14. The process of claim 13 wherein the preparing, the first contacting, the  
determining, and the multiplying steps are repeated until the adhesion tension  
value is 30 or below.

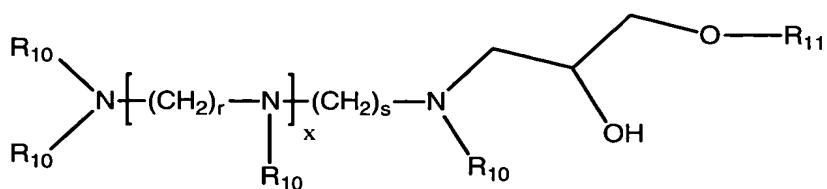
15 15. The process of claim 13 wherein the surface of the plurality of substrates in  
the second contacting step is wet with a deionized water rinse.

16. The process of claim 13 wherein the surface of the plurality of substrates is  
wet with a developer solution.

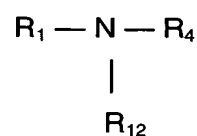
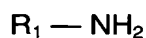
17. A process rinse solution to reduce at least one defect selected from pattern  
20 collapse and line width roughness on the surface of a substrate that has been  
patterned and developed, the solution comprising an aqueous solvent, a non-  
aqueous solvent, and at least one surfactant selected from the group of  
surfactants having the formula (I), (II), (III), (IVa), (IVb), (V), (VI), (VII), (VIII),  
(IXa), (IXb), (IXc), (Xa), (Xb), (Xc), or (Xd):







VIII

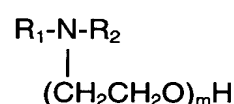
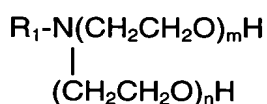
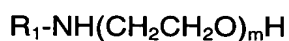


5

IXa

IXb

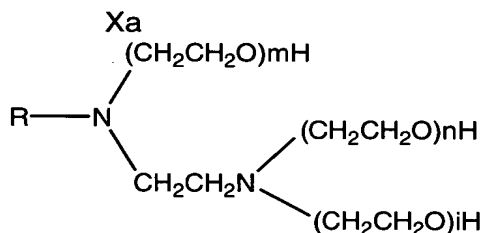
IXc



10

Xb

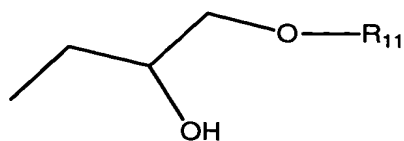
Xc



Xd

15

wherein R, R<sub>1</sub>, R<sub>4</sub>, and R<sub>12</sub> are each independently a straight, a branched, or a cyclic alkyl group having from 3 to 25 carbon atoms; R<sub>2</sub> and R<sub>3</sub> are each independently a hydrogen atom or a straight, a branched, or a cyclic alkyl group having from 1 to 5 carbon atoms; R<sub>5</sub> is a straight, a branched, or a cyclic alkyl group having from 1 to 10 carbon atoms; R<sub>6</sub> is a straight, a branched, or a cyclic alkyl group having from 4 to 16 carbon atoms; R<sub>7</sub>, R<sub>8</sub>, and R<sub>9</sub> are each independently a straight, a branched, or a cyclic alkyl group having from 1 to 6 carbon atoms; R<sub>10</sub> is a hydrogen atom or a group represented by the formula



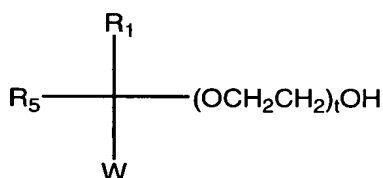
; R<sub>11</sub> is a straight, a branched, or a cyclic alkyl

25

group having from 4 to 22 carbon atoms; W is a hydrogen atom or an alkynyl group; X and Y are each independently a hydrogen atom or a hydroxyl group; Z is a halide atom, a hydroxyl group, an acetate group, or a carboxylate group; i, m, and n are each independently a number that ranges from 0 to 20; r and s are each independently 2 or 3; t is a number that ranges from 0 to 2; j is a number that ranges from 1 to 5; and x is a number that ranges from 1 to 6.

18. The process solution of claim 17 wherein the non-aqueous solvent is miscible in the aqueous solvent.

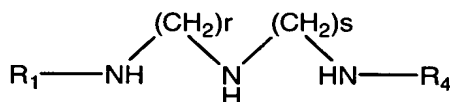
19. The process solution of claim 17 wherein the at least one surfactant is a surfactant having the following formula (III):



III

wherein  $R_1$  is a straight or a branched alkyl group having from 3 to 25 carbon atoms;  $R_5$  is a straight or a branched alkyl group having from 1 to 10 carbon atoms; W is a hydrogen atom or an alkynyl group; and t is a number that ranges from 0 to 2.

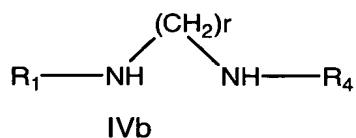
20. The process solution of claim 17 wherein the at least one surfactant is a surfactant having the following formula (IVa):



IVa

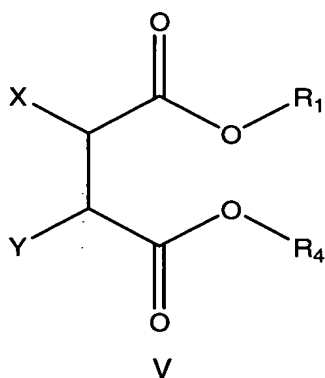
wherein  $R_1$  and  $R_4$  are each independently a straight or a branched alkyl group having from 3 to 25 carbon atoms and r and s are each independently 2 or 3.

21. The process solution of claim 17 wherein the at least one surfactant is a surfactant having the following formula (IVb):



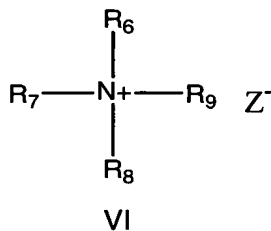
wherein R<sub>1</sub> and R<sub>4</sub> are each independently a straight or a branched alkyl group having from 3 to 25 carbon atoms and r is 2 or 3.

22. The process solution of claim 17 wherein the at least one surfactant is a surfactant having the following formula (V):



wherein R<sub>1</sub> and R<sub>4</sub> are each independently a straight or branched alkyl group having from 3 to 25 carbon atoms and X and Y are each independently a hydrogen atom or a hydroxyl group.

23. The process solution of claim 17 wherein the at least one surfactant is a surfactant having the following formula (VI):





alkyl group having from 4 to 22 carbon atoms; r and s are each independently 2 or 3; and x is a number that ranges from 1 to 6.

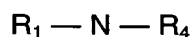
26. The process solution of claim 17 wherein the at the at least one surfactant is a surfactant having the following formula (IXa):



IXa

wherein R<sub>1</sub> is a straight, a branched, or a cyclic alkyl group having from 3 to 25 carbon atoms.

10 27. The process solution of claim 17 wherein the at the at least one surfactant is a surfactant having the following formula (IXb):



IXb

15 wherein R<sub>1</sub> and R<sub>4</sub> are each independently a straight, a branched, or a cyclic alkyl group having from 3 to 25 carbon atoms.

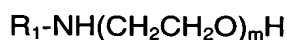
28. The process solution of claim 17 wherein the at the at least one surfactant is a surfactant having the following formula (IXc):



IXc

25 wherein R<sub>1</sub>, R<sub>4</sub>, and R<sub>12</sub> are each independently a straight, a branched, or a cyclic alkyl group having from 3 to 25 carbon atoms.

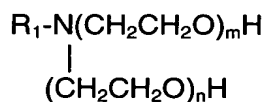
29. The process solution of claim 17 wherein the at the at least one surfactant is a surfactant having the following formula (Xa):



Xa

5 wherein  $R_1$  is a straight, a branched, or a cyclic alkyl group having from 3 to 25 carbon atoms; and  $m$  is a number that ranges from 0 to 20.

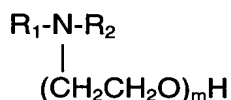
30. The process solution of claim 17 wherein the at the at least one surfactant is a surfactant having the following formula (Xb):



Xb

10 wherein  $R_1$  and  $R_2$  are each independently a straight, a branched, or a cyclic alkyl group having from 3 to 25 carbon atoms; and  $m$  and  $n$  are each independently a number that ranges from 0 to 20.

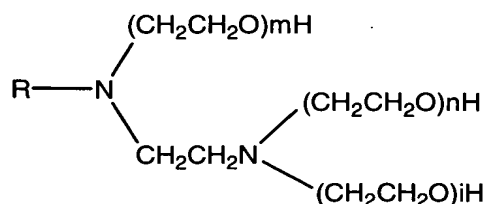
31. The process solution of claim 17 wherein the at the at least one surfactant is a surfactant having the following formula (Xc):



Xc

20 wherein  $R_1$  and  $R_2$  are each independently a straight, a branched, or a cyclic alkyl group having from 3 to 25 carbon atoms; and  $m$  is a number that ranges from 0 to 20.

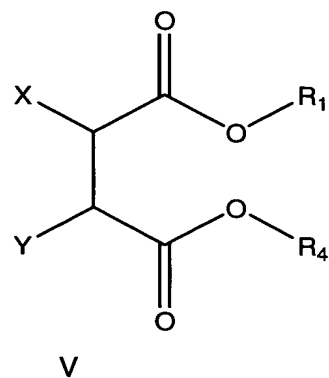
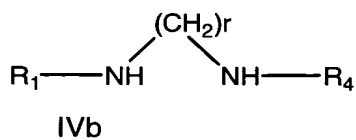
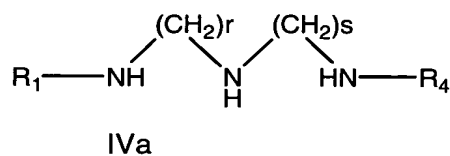
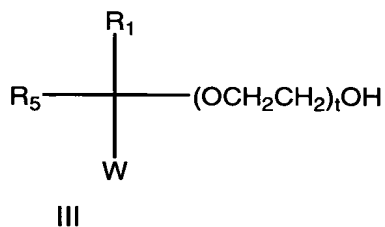
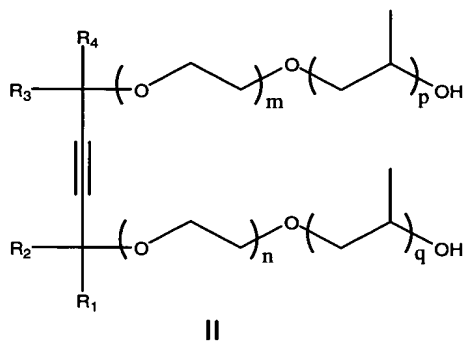
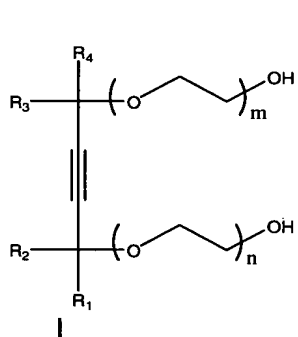
32. The process solution of claim 17 wherein the at the at least one surfactant is a surfactant having the following formula (Xd):

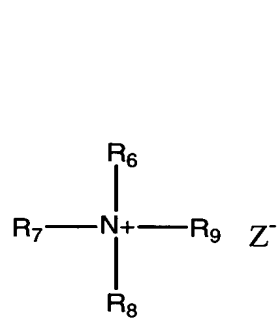


Xd

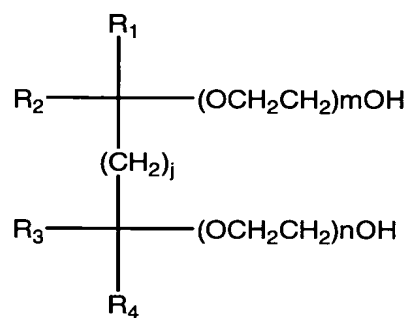
wherein R is independently a straight, a branched, or a cyclic alkyl group having from 3 to 25 carbon atoms; and i, m, and n are each independently a number ranging from 0 to 20.

33. A method of reducing pattern collapse defects on the surface of a patterned and developed substrate comprising: contacting the substrate with a process solution comprising an aqueous solvent, a non-aqueous solvent, and at least one surfactant having the formula (I), (II), (III), (IVa), (IVb), (V), (VI), (VII), (VIII), (IXa), (IXb), (IXc), (Xa), (Xb), (Xc), or (Xd):

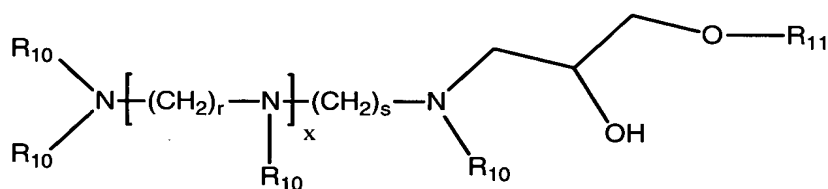




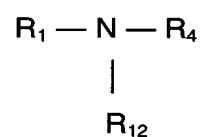
VI



VII



VIII

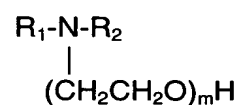
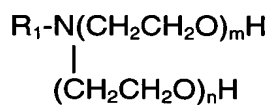
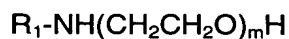


IXa

IXb

IXc

10

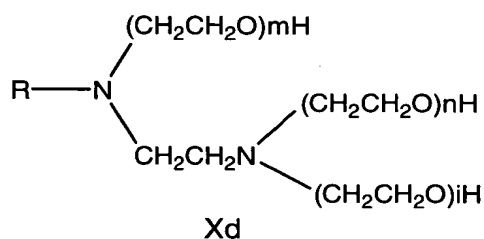


15

Xa

Xb

Xc

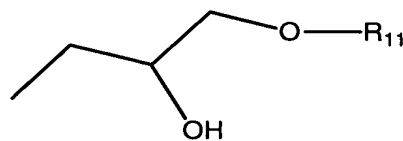


Xd

20 wherein R, R<sub>1</sub>, R<sub>4</sub>, and R<sub>12</sub> are each independently a straight, a branched, or a cyclic alkyl group having from 3 to 25 carbon atoms; R<sub>2</sub> and R<sub>3</sub> are each independently a hydrogen atom or a straight, a branched, or a cyclic alkyl group having from 1 to 5 carbon atoms; R<sub>5</sub> is a straight, a branched, or a cyclic alkyl group having from 1 to 10



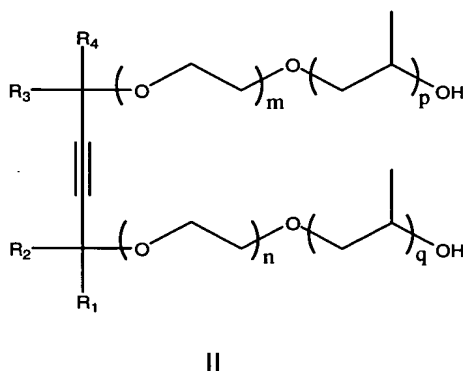
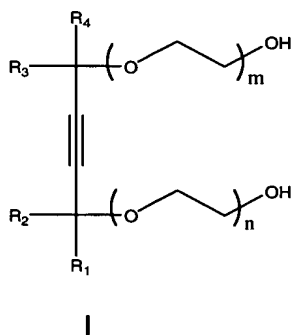
carbon atoms;  $R_6$  is a straight, a branched, or a cyclic alkyl group having from 4 to 16 carbon atoms;  $R_7$ ,  $R_8$ , and  $R_9$  are each independently a straight, a branched, or a cyclic alkyl group having from 1 to 6 carbon atoms;  $R_{10}$  is a hydrogen atom or a group

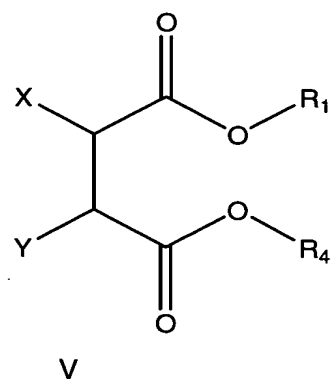
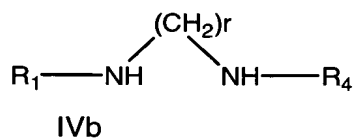
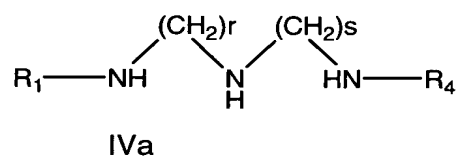
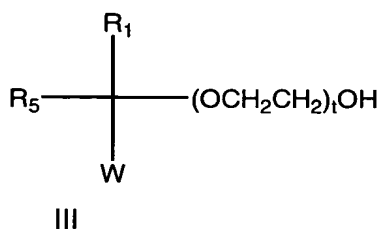


represented by the formula ;  $R_{11}$  is a straight, a branched,

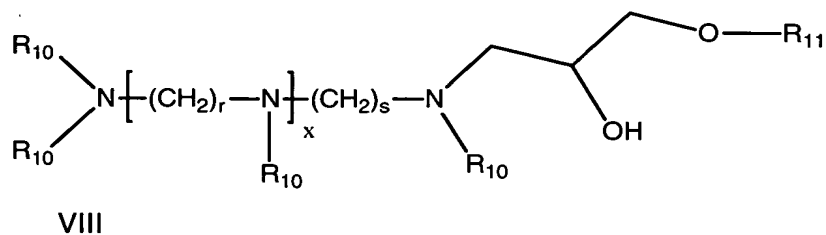
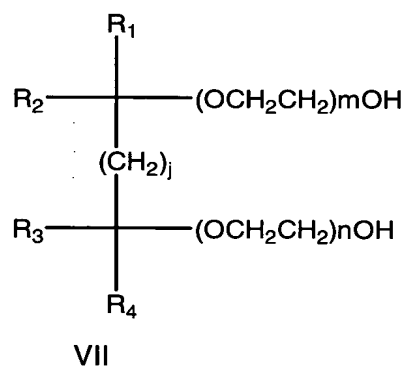
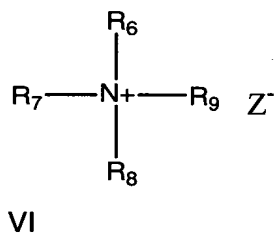
- 5 or a cyclic alkyl group having from 4 to 22 carbon atoms; W is a hydrogen atom or an alkynyl group; X and Y are each independently a hydrogen atom or a hydroxyl group; Z is a halide atom, a hydroxyl group, an acetate group, or a carboxylate group; i, m, and n are each independently a number that ranges from 0 to 20; r and s are each independently 2 or 3; t is a number that ranges from 0 to 2; j is a number that ranges
- 10 from 1 to 5; and x is a number that ranges from 1 to 6.

34. A method of reducing line width roughness defects on the surface of a patterned and developed substrate comprising: contacting the substrate with a process solution comprising an aqueous solvent, a non-aqueous solvent, and at least one surfactant having the formula (I), (II), (III), (IVa), (IVb), (V), (VI), (VII), (VIII), (IXa), (IXb), (IXc), (Xa), (Xb), (Xc), or (Xd):

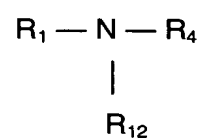
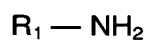




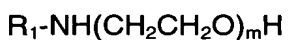
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10

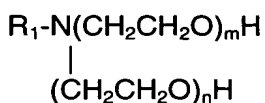


15

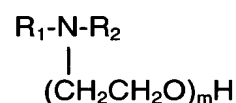


5

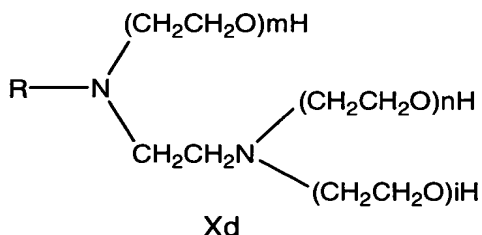
Xa



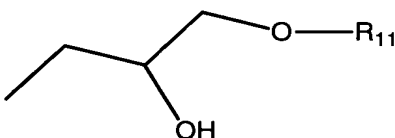
Xb



Xc



- 10 wherein R, R<sub>1</sub>, R<sub>4</sub>, and R<sub>12</sub> are each independently a straight, a branched, or a cyclic alkyl group having from 3 to 25 carbon atoms; R<sub>2</sub> and R<sub>3</sub> are each independently a hydrogen atom or a straight, a branched, or a cyclic alkyl group having from 1 to 5 carbon atoms; R<sub>5</sub> is a straight, a branched, or a cyclic alkyl group having from 1 to 10 carbon atoms; R<sub>6</sub> is a straight, a branched, or a cyclic alkyl group having from 4 to 16 carbon atoms; R<sub>7</sub>, R<sub>8</sub>, and R<sub>9</sub> are each independently a straight, a branched, or a cyclic alkyl group having from 1 to 6 carbon atoms; R<sub>10</sub> is a hydrogen atom or a group
- 15



represented by the formula

; R<sub>11</sub> is a straight, a branched,

or a cyclic alkyl group having from 4 to 22 carbon atoms; W is a hydrogen atom or an alkynyl group; X and Y are each independently a hydrogen atom or a hydroxyl group; Z is a halide atom, a hydroxyl group, an acetate group, or a carboxylate group; i, m, and n are each independently a number that ranges from 0 to 20; r and s are each independently 2 or 3; t is a number that ranges from 0 to 2; j is a number that ranges from 1 to 5; and x is a number that ranges from 1 to 6.

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